2014

LASER-WAKEFIELD ELECTRON ACCELERATOR WITH INDEPENDENT BEAM-PARAMETER CONTROL

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Plasma Sciences (ICOPS) held with 2014 IEEE International Conference on High-Power Particle Beams (BEAMS), 2014 IEEE 41st International Conference on
Year: 2014
Pages: 1 - 1, DOI: 10.1109/PLASMA.2014.7012361

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It has been demonstrated that laser-wakefield acceleration (LWFA) can generate several electron beam parameters rivaling those generated by conventional RF-cavity accelerators. Tunable and monoenergetic electron beams have also been produced with LWFA. Currently, active research is being directed towards finding methods to generate *e*-beams that have independently controllable parameters, as is standard in the case of conventional accelerators. One promising approach is to separate and independently control the essential acceleration processes.[2]

We report demonstration of such control with LWFA, by usage of a single laser pulse (33-fs duration, 1.7-J energy) and optimized plasma profiles, of density and atomic composition. As a result, we were able to generate stable, quasi-monoenergetic electron beams, and tune their central energy over the 50-140 MeV range, while preserving both their quality, charge (20 pC), and absolute energy spread (15 MeV). We also demonstrated the scalability of this approach, by independently increasing the acceleration length, and boosting the maximum central energy to 450 MeV.

The plasma profiles of the acceleration medium consisted of three distinct regions. In the first, the laser pulse evolved, self-focused, and formed an acceleration bubble. In the second, electrons were injected in the bubble via ionization-assisted injection. In the third region, electrons were accelerated by a laser wakefield, and the bunch underwent phase-space rotation. This seamless integration of electron injection and acceleration resulted in injection of electrons into acceleration bucket in the correct phase, utilizing the full length of accelerating field, and eliminating the problems associated with external synchronization.

The beam-parameter control that was enabled by this approach recently proved essential to the success of a novel source of quasi-monoenergetic and tunable x-rays, generated through LWFA and inverse Compton scattering.[3]

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[2]S. M. Hooker, *Nat. Photon.* **7**, 775 (2013)

[3]N. Powers et al., *Nat. Photon.* **8**, 28 (2014)